EXHIBIT A - ARRL REPLY COMMENTS

Errors Made in the IBEC Measurements of Ambient Noise Levels

Ed Hare
ARRL Laboratory Manager
225 Main St.
Newington, CT 06111
Tel: 860-594-0318
Email: w1rfi@arrl.org

Abstract

In the Further Notice of Proposed Rulemaking in ET Docket 04-37, IBEC provided a paper reporting a measurement it had made of ambient noise levels at a handful of location.s The conclusion that IBEC reached, based on this measurement, is that the FCC staff and others erred in determining that ambient noise levels have not increased to any significant degree with time.

The test methodology used by IBEC is flawed in a number of significant ways, leading to its measuring "ambient noise" that is mostly the noise of the loop antenna preamplifier used in the measurement, also influenced to some degree by the presence of strong licensed signals in the passband of the measurement. The noise floor of the test equipment used by IBEC is at least 10-15 dB higher than the median value of man-made noise on HF established by ITU-R P.372-8 (now ITU-R P.372-9). This ARRL paper outlines the incorrect test methodology used by IBEC and the results of the mistakes it made in making these measurements.

The report by IBEC seriously overestimates the ambient noise levels, using methodology that is fundamentally flawed. It provides insufficient justification to overturn long-accepted levels of noise that were determined by competent bodies such as the ITU using sound, not flawed, measurement techniques. The FCC should continue to use the noise levels described in ITU-R P.372-9 in determining what level of additional noise can be added to the spectrum without impacting licensed services.

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Noise floor

The first error made by IBEC is that its measurement of the purported noise floor of its test equipment is incorrect. Although IBEC did not include specific information about the test equipment used to make its measurement, it is a reasonable assumption, based on the graph showing the noise floor of its instrumentation, that it is using an EMC receiver with an active loop antenna with an antenna factor of approximately 10 dB, reasonably flat across the frequency range of the measurement[1]. ARRL is quite familiar with these antennas; it owns and uses an EMCO model 6502 active loop antenna.

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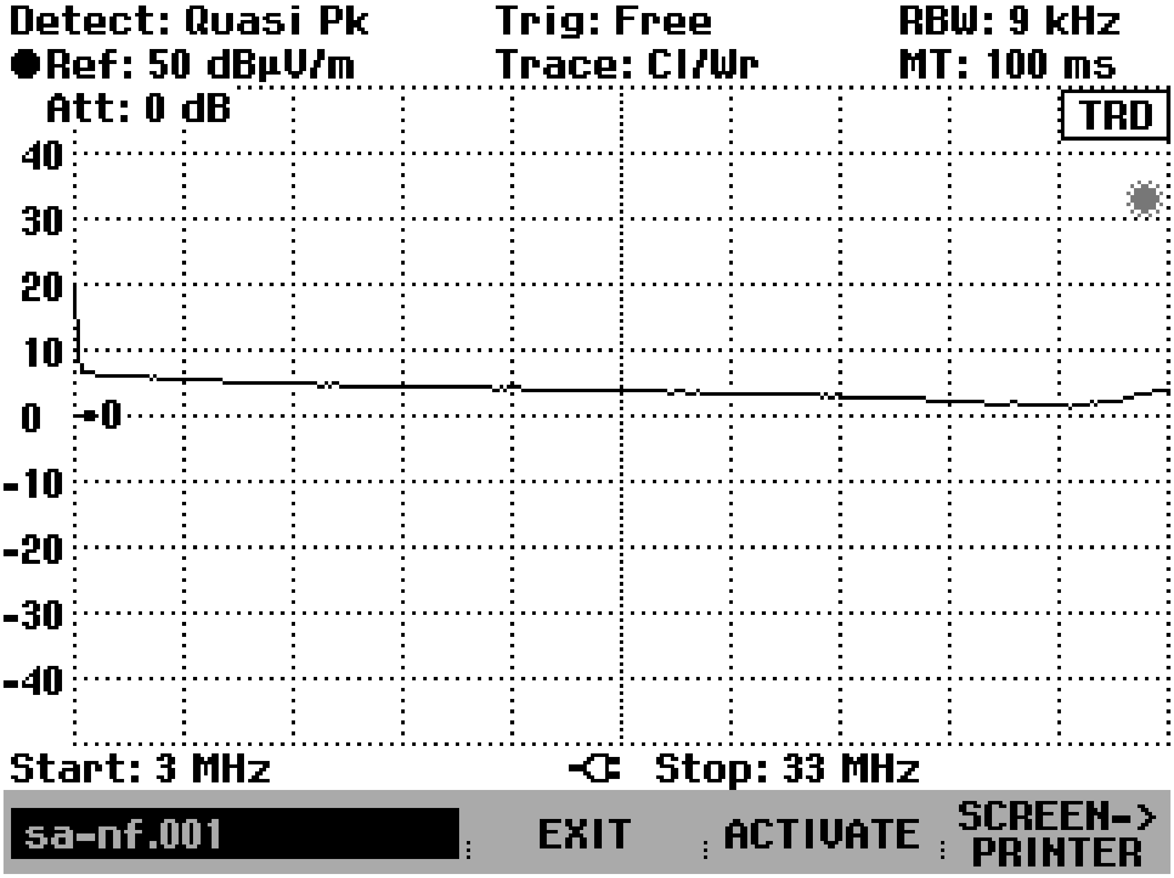
[1] One such loop antenna is the EMCO model number 6502, an antenna commonly used to make field strength measurements of signals near the FCC emissions limits.

IBEC showed a graph purporting to be a measurement of its test instrumentation. The results appear to be a measurement of the noise floor of the *EMC receiver* used to make the measurement. In general, as documented in the discussion below, the instrumentation noise in a radiated emission test using a small active loop is limited by the noise of the loop-antenna preamplifier, not the noise of the EMC-measurement instrument.

Figure 1 below is a graph that ARRL made of its Rohde and Schwarz spectrum analyzer, with the CISPR quasi-peak measurement option. The input of the analyzer was terminated with a 50-ohm resistor. These data have been corrected for the antenna factor of the EMCO 6502 loop, typically about 10 dB/m across most of the HF range. This graph shows a noise level close the level that IBEC reported as its instrumentation noise.



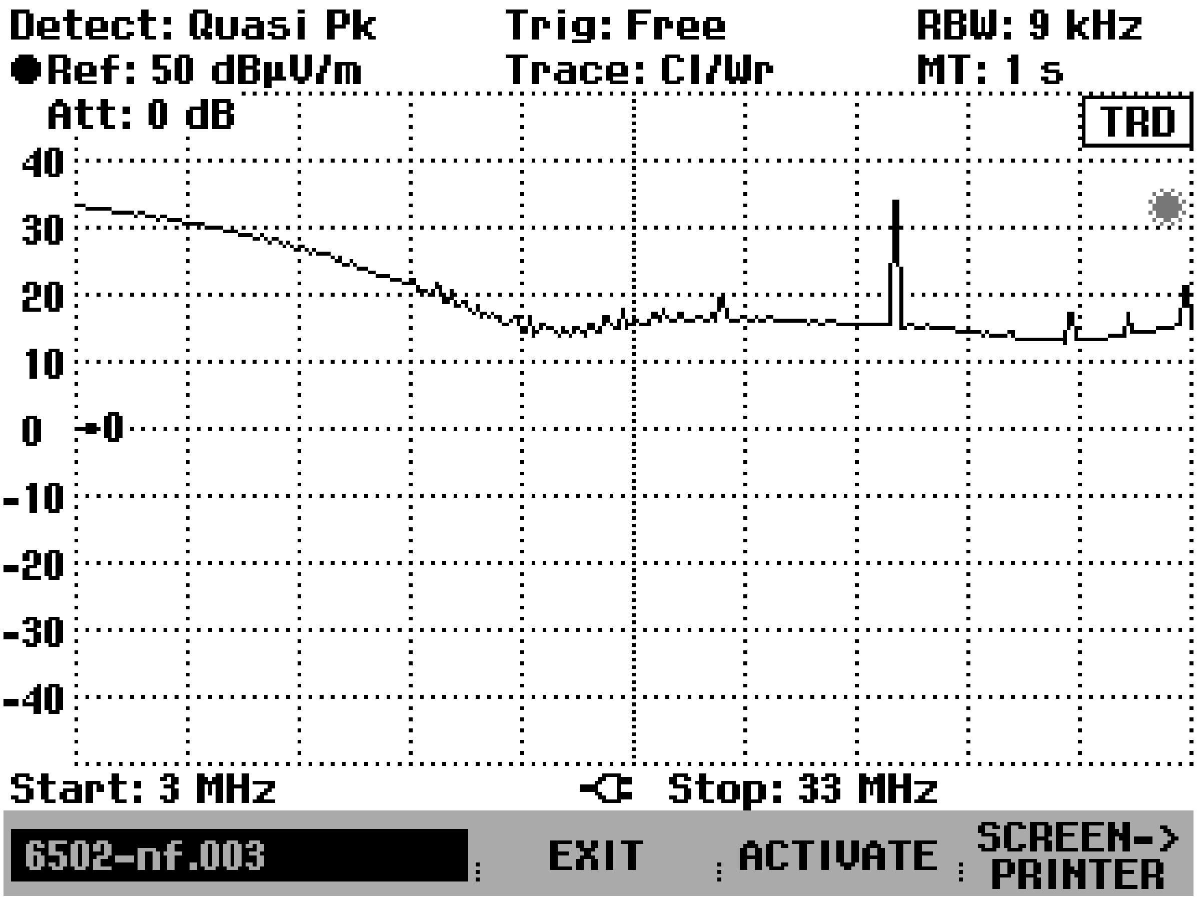
Detect: Quasi Pk
Trig: Free
RBW: 9 kHz
Ref: 50 dBµV/m
Trace: Cl/Wr
MT: 100 ms
Att: 0 dB
Start: 3 MHz
Stop: 33 MHz

Figure 1: Measurement of the noise floor of a Rohde and Schwarz FSH-3 spectrum analyzer, CISPR 9 kHz bandwidth, quasi-peak detector. These data have been corrected for the antenna factor of the EMCO 6502 loop that will be used to make radiated measurements.

However, the instrumentation noise in a measurement of field strength is typically not limited by the spectrum analyzer or EMC receiver used to make the measurement. *Non-amplified* loop antennas are very inefficient, typically with antenna factors as high as 40 dB/m. Adding a preamplifier boosts the signal from a small loop antenna to a usable level, but with the preamplifier noise as a limiting factor.

Figure 2 below shows a noise-floor measurement result that is typical and expected for an amplified small loop.   This measurement was made by ARRL, using an EMCO 6502 amplified loop antenna connected to a Rohde and Schwarz FSH-3 spectrum analyzer in its EMC receiver mode. The measurement is corrected for the 6502 antenna factors. This measurement was made in ARRL's shielded screen room, where the ambient noise level can be presumed to be much quieter than even a quiet rural outdoor area.

As seen in Figure 2, the output noise of the preamplifier in the loop antenna is much higher than the input noise of the spectrum analyzer, shown in Figure 1.   This measurement of the preamplifier noise of the loop antenna shows a measured noise floor that is only slightly lower than the lowest ambient levels IBEC reportedly measured at three locations. Because it erroneously assumed that the noise limitation of its test instrumentation was the noise of its EMC receiver, the ambient noise levels that IBEC measured and reported at or near this level of approximately +15 dBuV/m was instrumentation noise from an amplified loop antenna, not external ambient noise.



Detect: Quasi Pk
Trig: Free
RBW: 9 kHz
●Ref: 50 dBµV/m
Trace: Cl/Wr
MT: 1 s
Att: 0 dB
Start: 3 MHz
Stop: 33 MHz
6502-nf.003

Figure 2: Measurement of noise floor of loop antenna, tested in a shielded screen room. These data were measured using a CISPR quasi-peak detector in a 9 kHz measurement bandwidth. The data are corrected for the antenna factor of the EMCO 6502 antenna used for the measurement.

ARRL staff has considerable experience making measurements of field strength, using its calibrated test equipment and short monopole antennas.[2] This experience has shown that radiated ambient noise levels can be minus10 dBuV/m or lower in residential areas. This is tens of dB lower than the levels reported by IBEC, limited by its test equipment noise. This level of minus10 dBuV/m is very much in line with the levels of noise documented in ITU-R P.372-8 and by other work such as has been done in the field by FCC staff , NATO and others.

Frequency resolution of the measurement

The measurement of noise in the presence of active licensed users is a challenge. In the past, EMC receivers were used, with the test engineer listening to the signal to determine whether the signal being measured was noise or a desired signal. It is also necessary to determine at the time of the measurement that other signals at higher or lower frequencies are not impacting the results.

This impact from signals many tens of kHz away is caused by the 9 kHz bandwidth of the CISPR instrument (spectrum analyzer or EMC receiver). Filters, especially those used in CISPR-compliant instruments do not pass 9 kHz of signals and completely reject signals outside that passband. A typical filter has a bandwidth that is close to Gaussian distributed.

Figure 3 below shows the impact of this filter shape on a measurement. Strong licensed signals propagated via the ionosphere on HF can easily reach levels of +75 dBuV/m. Depending on the frequency, this can by 75 dB stronger than the median values of man-made noise in residential neighborhoods, based on the levels specified in P.372-8. Figure 3 shows a quasi-peak measurement of a 10 MHz carrier from a signal generator connected to the FSH-3 spectrum analyzer. The signal level is approximately 70 dB higher than the noise floor of the instrument, using a CISPR quasi-peak detector and a 9 kHz bandwidth. While this is a strong signal, such levels are not at all uncommon. (The IBEC study, apparently made using measurements every 50 kHz, shows several licensed signals in that amplitude range.)
The span of the measurement is 1 MHz.

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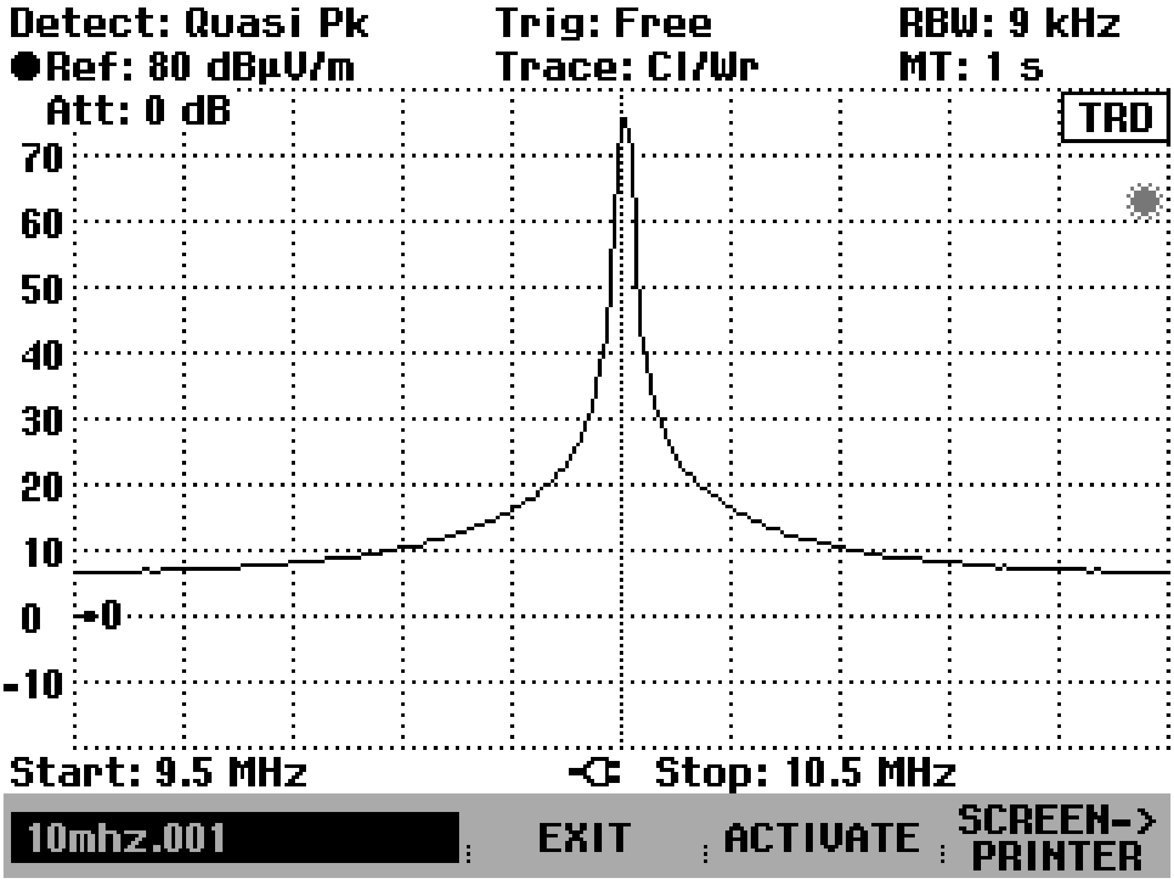
[2] ARRL has estimated the antenna factor of the "Iron Horse" brand center-loaded 8-foot whips by comparing received signal levels from these antennas with the received signal level on its EMCO 6502 calibrated loop antenna.



Detect: Quasi Pk
Trig: Free
RBW: 9 kHz
●Ref: 80 dBµV/m
Trace: Cl/Wr
MT: 1 s
Att: 0 dB
Start: 9.5 MHz
Stop: 10.5 MHz

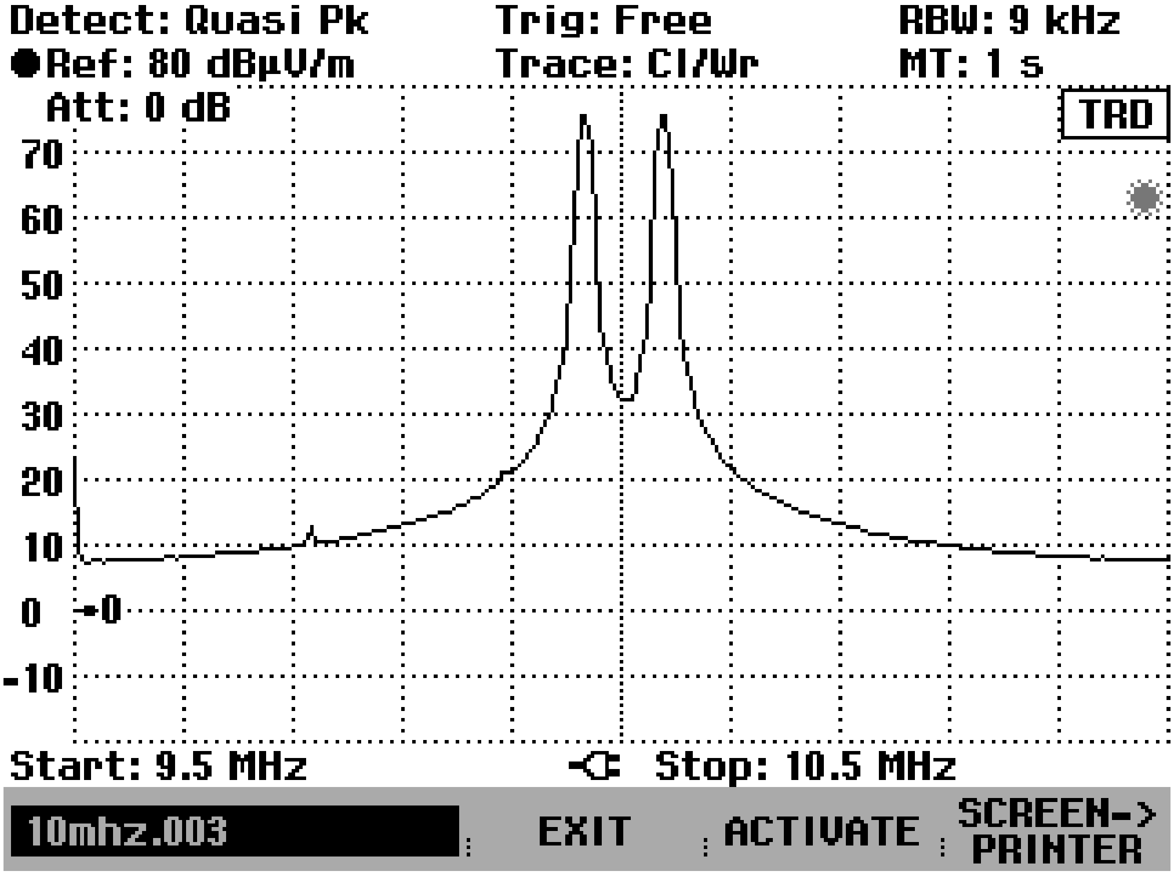
Figure 3 -- This measurement, made of an un-modulated carrier at 10 MHz, using a CISPR quasi-peak detector and a 9 kHz measurement bandwidth. The measurement shows the effect of the 9 kHz filtering in the FSH-3 spectrum analyzer. At a frequency more than 100 kHz from the carrier, the level of the "measurement" is at approximately +15 dBuV/m, close to the level that IBEC reported as "ambient noise" in its test report. Even if an EMC receiver and a sensitive antenna were used for IBEC's measurements, if the presence of stronger signals as much as 100 kHz from the measurement frequency were not considered, the result would overestimate ambient noise by at least 10-15 dB, and even more if the non-noise signal were closer in frequency than 100 kHz..

Modern signal measuring techniques use a narrower bandwidth to more accurately estimate the levels of noise in the presence of stronger licensed signals.

The presence of more than one strong signal in the passband of the measurement makes the bandwidth problem even worse. Figure 4 below shows the effect of a mere *two* such strong signals. The levels of these signals are set to represent a level of +75 dBuV/m.

The two signals shown in Figure 4 are at frequencies of 9.964 and 10.036 MHz, representing a spacing of eight 9-kHz measurement channels. As can be seen, although there are 6 unoccupied measurement-bandwidth channels in between those two signals, the filter characteristics of the

CISPR-compliant filter have degraded the measurement in those channels to a level of approximately +32 dBuV/m at the midpoint between the two signals. (There is even worse degradation at closer spacing. This represents a “measurement” on those unoccupied channels that is approximately 30 dB greater than the levels described in ITU-R P.372-8 as the median value of man-made noise. However, in the presence of these off-channel signals, the measurement is not of the ambient noise in these unoccupied channels, it is a measurement of a point down the slope of the 9 kHz filter used in the test instrument.



Detect: Quasi Pk
Trig: Free
RBW: 9 kHz
●Ref: 80 dBµV/m
Trace: Cl/Wr
MT: 1 s
Att: 0 dB
Start: 9.5 MHz
Stop: 10.5 MHz
10mhz.003

Figure 4 -- This measurement of two un-modulated carriers shows how the filter characteristics of CISPR-compliant measurement instruments can degrade the ability to measure low-level signals. Although the spectrum between these carriers is unoccupied, the instrument reports a level of +32 dBuV/m at the midpoint, approximately 30 dB higher than the instrumentation noise floor.

This frequency spacing represents approximately 26 communications channels on HF, assuming a 3 kHz channel bandwidth. If only two of those channels were occupied, a spectral occupancy of about 8%, the ability to measure noise on unoccupied channels would be limited by the test instrumentation to a level of about +30 dBuV/m at best, and possibly much worse. When measurements in the presence of multiple licensed signals are made by inexperienced test engineers, this is the level that would likely be incorrectly reported as the “ambient noise level,” even though actual noise levels would almost certainly be significantly lower.

Although the exact filtering shape of the instrument that IBEC used to make its test isn’t included in the report, it is reasonable to conclude that the results from the Rohde and Schwarz FSH-3 are typical of what is seen in CISPR-compliant equipment. The IBEC results could be influenced a few dB more, or less, by slightly different filter shape, but the impact of real-world instrumentation bandwidth on measurements of low-levels signals or noise in the presence of stronger signals on nearby frequencies is a major limitation on the ability to make accurate measurements.

EMC receivers and amplified loop antennas were designed to do one thing well -- make measurements of emissions that are near the FCC emissions limits, in close proximity to the radiating device. Trying to use such test equipment for other purposes can sometimes be done, but only if one is experienced in the use of the test equipment and its limitations.

Radiated intentional signals

It is a common error for inexperienced test engineers to make a sweep of spectrum and report that measurement as a measurement of "ambient noise." This is incorrect. A sweep, as shown by IBEC, from 3 to 30 MHz, with an antenna connected, is measuring ambient signals, not noise. The vast majority of those signals being measured are from intentional emitters, representing the desired signal in most cases. To characterize this as "noise" and report same as being noise is simply incorrect. In fact, in a broadband sweep using a measurement bandwidth of 9 kHz, the resolution of the test method, with a bandwidth that is typically broader than the channel bandwidth used by intentional emitters, the measurement bandwidth causes the stronger intentional signals to mask the ambient noise that is between them. This combination of factors, instrumentation noise, instrument limitations and misinterpretations seriously overestimated the ambient noise levels.

NATO Testing

Other competent bodies have done accurate and thorough testing of ambient noise levels. NATO has published a study, “*Potential Effects of Broadband Wire-Line Telecommunications on the HF Spectrum*,” that shows, among other things, that recent measurements of man-made noise are approximately the same as those described in ITU-R P.372-8[3] and that they have not changed substantially over time.

The following is an excerpt from this NATO report:

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[3] The levels are generally lower, although it is still a reasonable assumption that the P.372-8 data are still a reasonable starting point to use for engineering and regulatory decisions.

ELECTROMAGNETIC AMBIENT NOISE ENVIRONMENT

In all radio communications, the limiting factor is the ability to receive weak signals against the background noise. However, because of the characteristics of the HF band, this background noise is not the noise generated in the receiver (as it is on VHF and higher frequencies), but the ambient noise in the external environment. In effect this noise enters the receiver via the antenna along with the wanted signals, so that the radio environment influences the receiving process.

The ambient noise environment consists of two parts, the irreducible residual natural (atmospheric and cosmic) noise, and incidental man-made noise from local sources. The combination of these two determines the minimum usable signal level.

The ambient noise floor has been measured by several organisations including the ITU-R, the British BBC, DERA (Defence Evaluation & Research Agency, now DSTL) and RSGB (Radio Society of Great Britain) and the German TST (Telefunken Systemtechnik). The noise survey requires the selection of a radio frequency that is not occupied by an existing radio signal. It is almost impossible to find spot frequencies where there is a 9 kHz band without any signals. Because of this congestion, sweeping the HF band using an EMC measuring receiver with a 9 kHz bandwidth does not measure the background noise level. Additionally, measurements made with a typical loop EMC measuring antenna will be limited by the noise of the receiver system, not the environmental noise.

To carry out a swept measurement of the true ambient noise floor at HF, a much narrower bandwidth than 9 kHz – in the order of 100 – 200 Hz – should be used, and the noise produced by the measuring system itself has to be lower than the ambient noise to be measured. The results of the noise measurement are then converted to a 9 kHz bandwidth for comparison purposes with field strength limits which rely on that bandwidth in the HF-range.

Usually, it is impractical to measure the ambient noise floor in industrial or business locations where the man-made noise will exceed the natural noise floor. The best locations for measuring the ambient noise floor without being influenced by man-made noise will be in rural or in quiet rural areas. In interpreting published plots of the ambient noise floor, it is important to take into account the conditions of measurement, particularly the bandwidth and the detector used (peak, quasi-peak, or average), and the type of antenna.

In the course of the studies, the RTG determined that ITU-R Recommendation P.372-8 noise curves (based on measurements carried out in the 1970s) are still valid in Europe. Recent measurements carried out in Germany and Great Britain indicated that there is no marked difference between these measurements, specifically no increase of the ambient noise in quiet rural zones within the last 30 years, as shown in Figure 2.

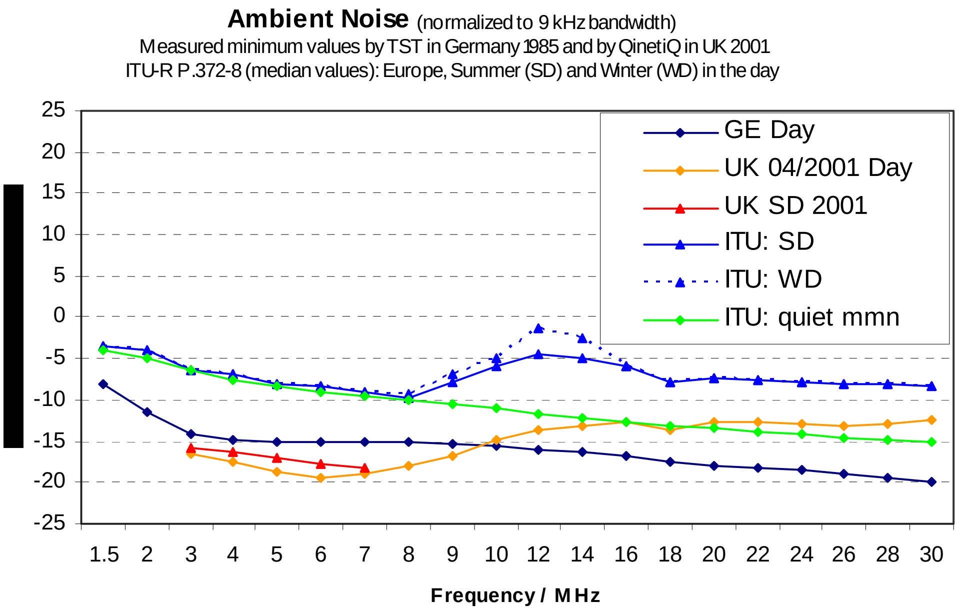

Figure 2: Minimum ambient natural noise measured in Germany 1985 and in UK 2001 and ITU-R Recommendations for median natural and man-made noise in Europe (mmn: median man-made noise in quiet rural areas)

The NATO report also covers other topics, such as a comparison of the emissions limits of various countries. Here is another excerpt from the same report:

WIRE-LINE EMISSION LIMITS

Currently, there are several existing/proposed electric field strength emission limits for wire-line communications, specified at a distance of 3 metres or 10 metres (North America), and specified in different values. In the HF band, these limits, (all converted to a distance of 3 metres to the line, and in peak values), range between 0 to 74 dBµV/m, depending on the country or the organization. Figure 1 shows the existing/proposed limits at the time of study. It is also known that other nations such as South Africa, Japan, South Korea, China, India, and Australia were in the experimental phase of performing PLT field trials. Proposals by these nations for field strength or common mode current limits were not available during the RTG's study period.

The international regulatory framework has not reached a consensus on emission limits. The broadband wire-line telecommunication technology is promoted globally, in order for everyone to have the means of exchanging large amounts of data for Internet applications. A cost effective and practical way is to use the existing wire-line infrastructure, i.e., power and/or telephone lines. Power lines are widespread, but have the worst technical characteristics for emitting broadband noise-like signals, when transmitting high data rate signals (several Mbps). While there is not much experience regarding radio interference from PLT data communications *technology, in the meantime commercial interests are promoting its widespread implementation. It would take some time for the radio interference experience to be gathered and the subsequent regulatory framework to be developed, preferably harmonized internationally. In the meantime, the regulatory authorities recommend that measures be taken to minimize such interference to other users.*

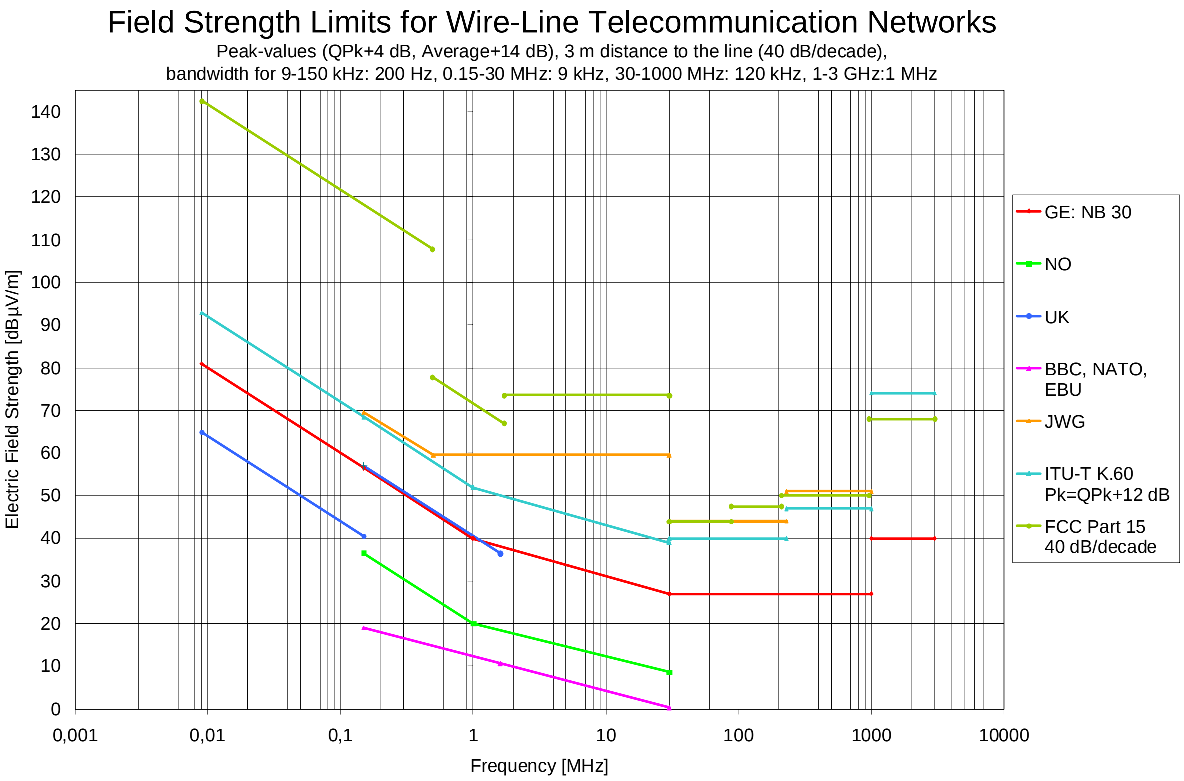

Figure 1: Field strength limits proposed for broadband wire-line telecommunication networks. All limits extrapolated to 3 metre measurement distance.

Comparing these limits with the median values of man-made noise shows that, for some nations, the permitted limits are at a very high level compared to the signal levels that will be used on HF spectrum.

Test-result reporting

The report provided by IBEC is seriously lacking in the types of information commonly included in such reports. Just as a few examples, date and time of day, the equipment used, the locations of the testing and the proximity of the location to power lines were not included. The "business" measurement was cited as being located 50 meters from any building, but no indication was made of the proximity of distance from the power lines. The report also indicates that this "business" location was also

located in close proximity to a commercial open-area test site (OATS), a location typically chosen for low noise. Few EMC professionals would characterize a location that is 50 meters from buildings and close to an OATS as a typical business location for measurement of man-made noise.

The omission of some of this information is of direct bearing on any interpretation of the results of IBEC's testing. As just one example, there is a tremendous variation in noise levels with time of day on any given HF frequency. The graph below, taken from a published NATO study, "*HF Interference, Procedures and Tools*[4]*,*", shows that on some frequencies, the signals and noise on any HF communications channel can vary by as much as 70 dB. (Other studies have shown an even greater variation.)

NATO
OTAN

HF RADIO

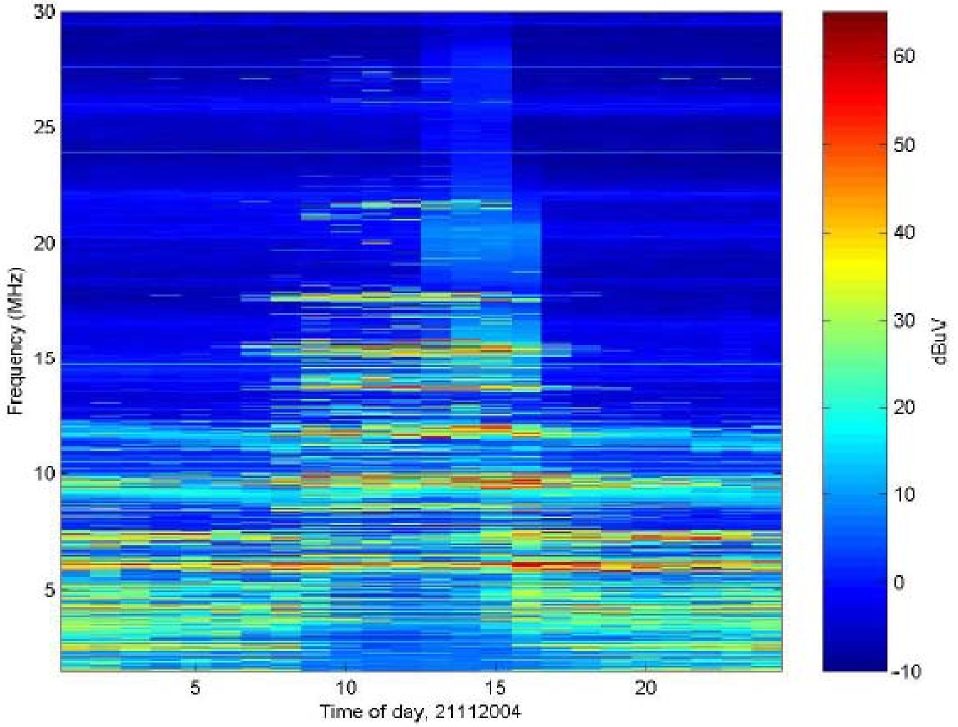

Figure 2.2.2-2: HF Spectrum Measured in Norway during One Day in November 2004
(2 – 30 MHz, measurement bandwidth 9 kHz, average energy measured over 10 ms intervals).

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[4] This report is available from http://ftp.rta.nato.int/public//PubFullText/RTO/TR/RTO-TR-IST-050///$$TR-IST-050-ALL.pdf.

Summary

The measurement of radiated field strength *in-situ* is not an easy task. This is *especially* true for the measurement of noise that is ten or more dB lower than the noise floor of the measurement instrument. This is also true for the measurement of low-level signals in the presence of much stronger signals located as much as 100 kHz or more away. There are techniques for making such measurements. These include the use of physically large antennas, such as were used in the 1970s work that measured noise levels used in ITU-R P-372.8. Smaller 8-foot monopoles can also be used effectively to ensure that the noise level being measured is stronger than the instrument noise. Narrow bandwidths can be used, extrapolated to 9 kHz using a $10\log_{10}$ (bandwidth ratio) for noiselike signals (or a $20\log_{10}$ (bandwidth ratio) for impulse signals). The presence of strong off-channel signals can also be searched for during testing, to ensure that any data that are corrupted by out-of-bandwidth signals is not falsely reported.

None of these techniques was used by IBEC. It simply connected a test antenna to an EMC receiver, swept the spectrum and reported that the noise seen by the minimum levels of the signal seen on the receiver was "ambient noise," irrespective of the fact that it was the loop preamplifier noise, not radiated ambient noise, that was being reported and irrespective of the fact that the measurement limit of its test instrumentation was further degraded by the interaction of strong radiated licensed signals with the relatively wide 9 kHz bandwidth of its CISPR-compliant test equipment. IBEC's test results are quite insufficient to warrant overturning the results of testing done by more competent and thorough bodies. Using more appropriate test equipment, FCC staff found ambient noise levels to be lower than the levels described in P.372-8. The NTIA Phase I study made a similar finding. Work done by ARRL submitted during earlier parts of the BPL rulemaking proceeding showed similar results.

The NATO report cited in Footnote 3 reached the same general conclusion:

> *"ITU-R P.372-8 noise curves (based on measurements carried out in the 1970s) are still valid in Europe. Recent measurements carried out in Germany and Great Britain indicated that there is no remarkable difference between these measurements, specifically no increase of the ambient noise in quiet rural zones within the last 30 years."*

Clearly, the data that IBEC has erroneously provided do not trump the larger body of information provided by competent authority. The FCC should continue to rely on the competent findings of the ITU-R and other competent authority as the basis for determining what impact permitted noise levels are expected to have on various licensed services.

Other useful references:

EMC Testing: Using Spectrum Analyzers in Commercial EMC Testing, Schaefer, W., Conformity, http://www.conformity.com/artman/publish/printer_167.shtml

EMI Measurements, Test Receiver vs. Spectrum Analyzer, Rohde and Schwarz application note, http://www.ieee.li/pdf/essay/receiver_v_sa.pdf